



Attempted ignition of petrol vapour by lit cigarettes and lit cannabis resin joints

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ABSTRACT

A recent murder enquiry prompted experimentation to confirm and visually demonstrate that lit cigarettes are not a viable source of ignition of petrol vapour. In addition, tests comprising the attempted ignition of petrol vapour using hot and smouldering cannabis resin were also undertaken. A series of experiments was also designed to recreate circumstances specific to the crime under investigation by undertaking cigarette/joint ignition tests involving a mannequin clothed in a cotton garment onto which petrol was applied. The ultimate aim of the experiments was to produce a visual aid for use during court proceedings. Thirty nine (39) ignition attempts that involved exposing lit commercial cigarettes, hand-rolled cigarettes and cannabis resin joints to petrol vapour were undertaken; ignition was not achieved in any of the scenarios. In addition, a single attempt to ignite petrol vapour emanating from a pool of liquid fuel was effected with a smouldering piece of cannabis resin; no ignition occurred. In all cases the petrol was clearly present within the limits of flammability since ignition was subsequently effected using a naked flame.

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1. Introduction

From the authors' collective experience, there is a commonly held misconception that petrol vapour can be ignited via lit cigarettes. Whilst the flame of a lit match or cigarette lighter can certainly ignite petrol vapour, there have been no reported scientific experiments where petrol vapour has been ignited by a lit cigarette [1]. Consequently, it is generally accepted within the scientific community that, even when the ash is knocked off and it is puffed strongly, a lit cigarette will not ignite petrol vapour. A recent murder enquiry prompted a series of experiments specific to the circumstances of the case to record such observations visually for use during the court proceedings.

The aim of this paper is not to describe the combustion processes that occur within a cigarette or those required for the ignition of flammable gases and vapours, since the ample literature explaining these phenomenon is conveniently summarised in Holleyhead's two papers [1,2]. Nonetheless, it is useful to re-visit some of that information within this article where relevant.

Once lit, a cigarette burns via smouldering combustion. When puffed, the tip of the cigarette glows with a characteristic pale red glow; this is the hottest area of the cigarette where temperatures can reach up to 950 °C. The temperature of the cigarette tip can, however, decrease to around 600–700 °C when not puffed [1]. There are many reasons why the glowing cigarette coal cannot be treated as a hot surface; for example, the surface is not at uniform temperature nor is

it homogeneous, compositionally or geometrically, and competing combustion processes at the cigarette tip cause imperfect, localised reaction environments. However, when contemplating the possibility of igniting gases or vapours with a lit cigarette, it is perhaps easiest to simplify matters by considering the principles of hot surface ignition.

There are many factors involved in the hot surface ignition of gases/vapours, such as the temperature, emissivity (i.e. how efficiently energy is radiated away from the surface) and size of the surface, the contact time between the surface and gas/vapour, the minimum ignition energy and the quenching distance of the gas/vapour [1]. Although petrol vapour will auto-ignite (burst into flame without a pilot flame or spark) between 480 and 550 °C, experiments investigating hot surface ignition revealed that the temperature of a hot surface needed to reach 980–1130 °C before ignition of petrol vapour occurred [1]. Indeed, contrary to what might be expected, it is not simply the *temperature* of the surface that is the most crucial factor in determining whether ignition might take place; one of the most important factors to consider is the *energy transfer* between the hot surface and the petrol vapour, and in this respect the residence time and surface area play equally important roles [3].

For the specific case in question, the consideration of hot surface ignition of petrol vapour was of legitimate interest since the defence proposed the ignition of petrol vapour by "bombers" (small pieces of hot cannabis resin) falling from a lit cannabis resin joint when the smoker puffed on the joint. In this respect, the "bombers" were considered as a hot surface and it was that mechanism of ignition that merited consideration.

As soon as a "bomber" leaves the hot environment of the joint, it will immediately start to decrease in temperature; in fact, the heat losses are likely to be significant due to the large surface area to mass

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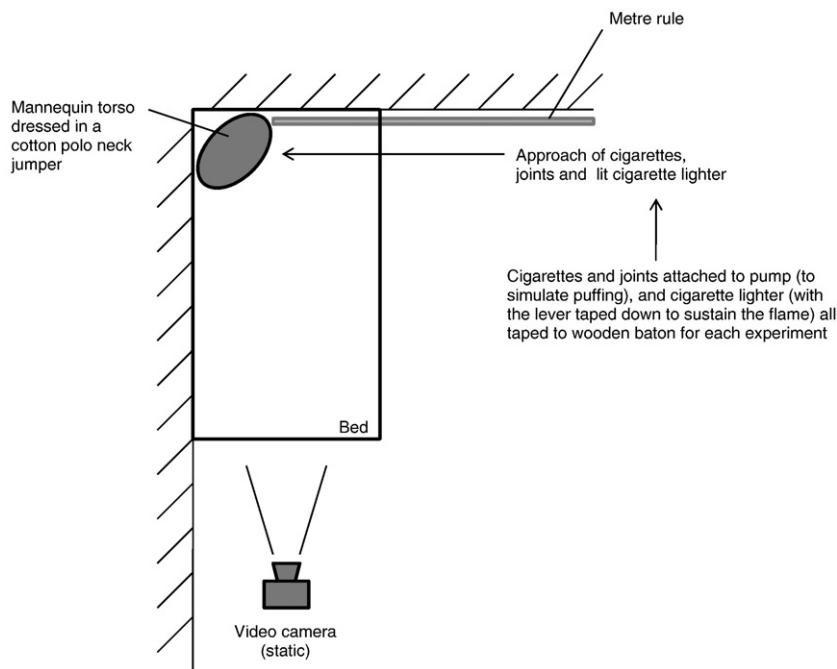


Fig. 1. Plan of the mannequin experimental set-up.

ratio. Consequently, it was considered highly unlikely that there would be sufficient energy transfer between the [cooled] surface of the “bomber” and any petrol vapour to cause ignition. Nonetheless, whilst informal enquiries by the principal author with fellow fire investigators [4–6] revealed that numerous experiments had been undertaken (but not published) involving lit cigarettes and petrol, a review of the literature did not reveal any experimentation where the ignition of petrol vapour had been attempted using hot/smouldering cannabis resin. Accordingly, two series of experiments were designed involving commercial cigarettes, hand-rolled cigarettes and cannabis resin joints.

2. Materials and methods

Two sets of experiments were undertaken, the first of which comprised attempting to ignite the petrol vapour produced above a pool of liquid fuel using lit commercial and hand-rolled cigarettes and also with lit cannabis resin joints. An additional experiment was also undertaken using a smouldering piece of cannabis resin alone.



Photograph 1. Attempted ignition of petrol vapour using a lit commercial cigarette.

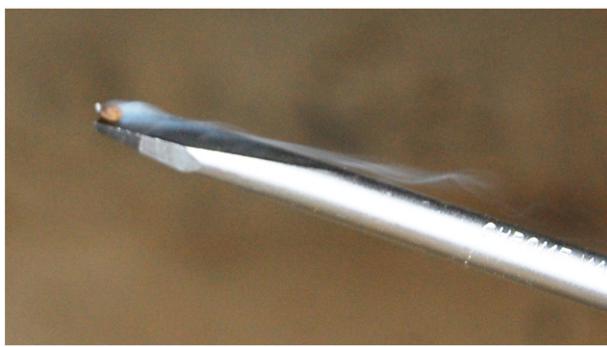
The second set of experiments was designed to recreate circumstances specific to the murder case under investigation. These tests involved placing a mannequin torso onto a bed located in the corner of an open-fronted compartment. The mannequin was dressed in a cotton polo neck jumper and positioned as shown in Fig. 1.

Three scenarios were undertaken in an attempt to ignite different volumes of petrol applied to the polo neck jumper, as described in Section 3 below.

The materials used were purchased specifically for these experiments. The commercial cigarettes were Benson & Hedges Gold, whilst the hand-rolled cigarettes and joints were made using regular red Rizla cigarette papers (medium weight, corners not cut) and Golden Virginia rolling tobacco. All of the joints were made with approximately the same amount of [crumbled] cannabis resin, mainly located in the tip of the joint. No filters were used in the hand-rolled cigarettes or joints. The petrol was 95 RON ULP purchased from the Shell filling station at Birchanger, Hertfordshire.



Photograph 2. Attempted ignition of petrol vapour using a lit cannabis resin joint.



Photograph 3. A simulated "bomber": a piece of smouldering cannabis resin.

The tests were undertaken in relatively still air and at an ambient temperature of approximately 15 °C. Following ignition, the flames were extinguished using a carbon dioxide fire extinguisher. All experiments were recorded using video and still photography. The surface temperatures of the cigarette/joint coals and the piece of smouldering cannabis resin were not measured.

3. Experimental

3.1. Petrol pool experiments

This series of experiments involved pouring petrol into a metal tray (to a depth of approximately 1.5 cm) and attempting to ignite the petrol vapour using lit commercial cigarettes, hand-rolled cigarettes and cannabis resin joints. Ten (10) lit commercial cigarettes were held between 20 and 50 cm above the petrol surface ([Photograph 1](#)) and the ash repeatedly tapped off, to decrease the insulation effect of the ash, prior to dropping the [lit] cigarette into the pool of petrol.

The tests were repeated with ten (10) lit hand-rolled cigarettes and subsequently with ten (10) lit cannabis resin joints ([Photograph 2](#)).

The aim of the above tests was to investigate whether the vapour emanating from a pool of liquid petrol could be ignited by [non-puffed] lit cigarettes or cannabis resin joints.

A penultimate test was undertaken by igniting one small piece of cannabis resin ([Photograph 3](#)) and dropping the smouldering "bomber" into the tray of petrol from a height of approximately 10 cm above the surface of the liquid. Since this was a previously unplanned part of the experiment, it was not possible to weigh the piece of cannabis resin used; however its dimensions were approximately 3 × 3 × 2 mm (visual estimation of w, l, h).

Finally, a lighted cigarette lighter was used to ignite the tray of petrol to demonstrate that the petrol vapour was present within its flammability limits.

3.2. Mannequin experiments

The aim of this series of tests was to investigate whether the petrol vapour emanating from a garment onto which different volumes of petrol had been applied could be ignited by [puffed] lit cigarettes or cannabis resin joints.

3.2.1. Mannequin Experiment 1

The first mannequin scenario involved applying 50 mL of petrol onto the bottom section of the front of the jumper. Subsequently, an attempt was made to ignite the petrol vapour using a lit commercial cigarette attached to a pump designed to simulate puffing of the cigarette ([Photograph 4](#)). The air flow through the pump was varied between constant flow (to maintain combustion at the coal) and an enhanced flow (to simulate a person "drawing" or puffing on the cigarette); the velocity of air was not measured.

Following this, ignition was attempted with a lit hand-rolled cigarette attached to the pump. Subsequently, an attempt was made to ignite the petrol vapour with a lit cannabis resin joint attached to the pump.

Finally, a lighted cigarette lighter was moved slowly downwards from the neck of the polo neck jumper towards the area of spilled petrol to demonstrate that naked flame ignition was possible ([Photograph 5](#)).

3.2.2. Mannequin Experiment 2

The second mannequin scenario involved re-clothing the mannequin with a new polo neck jumper and applying 0.5 L of petrol onto the bottom section of the front of the garment ([Photograph 6](#)).



Photograph 4. Attempted ignition of spilled petrol on a cotton jumper using a lit commercial cigarette attached to a puffing machine.



Photograph 5. Ignition of the petrol vapour emanating from the mannequin's jumper using a lighted cigarette lighter.

Ignition was attempted in the same manner as described in Section 3.2.1, using a lit commercial cigarette, a lit hand-rolled cigarette and a lit cannabis resin joint; all were attached in turn to the pump to



Photograph 7. Splashing petrol onto the mannequin's jumper by slapping the side of a jerry can.

simulate puffing. Finally, ignition was effected using a lighted cigarette lighter.

3.2.3. Mannequin Experiment 3

The third mannequin scenario involved re-clothing the mannequin with a new polo neck jumper and placing a jerry can filled with 5.67 L of petrol in front of the mannequin. The lid was removed and the jerry can was slapped on the side several times in an attempt to cause the liquid petrol to splash onto the jumper (Photograph 7).

Approximately 20 mL of petrol (volume visually estimated) eventually splashed onto the bottom section of the jumper before ignition was attempted in the same manner as before (Sections 3.2.1 and 3.2.2) using a lit commercial cigarette, a lit hand-rolled cigarette and a lit cannabis resin joint; all were attached in turn to the pump to simulate puffing. Finally, ignition was effected using a lighted cigarette lighter.

During each of the mannequin tests (Sections 3.2.1, 3.2.2 and 3.2.3), the glowing coals of the cigarettes/joints were touched against the area of the jumper that was wet with liquid petrol (Photograph 8) as well as being moved (at close proximity) over the wetted surface of the jumpers.

4. Results and discussion

In the thirty (30) ignition attempts during which lit commercial cigarettes, lit hand-rolled cigarettes and lit cannabis resin joints were held over the surface of a tray of petrol and dropped therein, ignition of the petrol vapour did not occur. Ignition also did not take place when one attempt was effected whereby a simulated cannabis resin "bomber" was dropped into the pool of liquid petrol from a height



Photograph 6. Application of 0.5 L of petrol to the mannequin's jumper.



Photograph 8. The lit tip of the cannabis resin joint touching the petrol-soaked area of the mannequin's cotton jumper (test shown: attempted ignition after slapping the side of a jerry can to cause petrol to splash onto the jumper).

of around 10 cm; the “bomber” dimensions were approximately $3 \times 3 \times 2$ mm (visual estimation of w, l, h). The concentration of petrol vapour produced above the surface of the pool of petrol was evidently present within the flammability limits since ignition was easily effected using a lighted cigarette lighter.

In total, nine (9) ignition tests were undertaken using lit commercial cigarettes, lit hand-rolled cigarettes and lit cannabis resin joints and different volumes of petrol applied/spilled onto the cotton jumper with which the mannequin was clothed. Puffing of the cigarettes/joints was simulated using a pump and this caused the tip of the cigarettes/joints to glow; however, even when the glowing cigarette/joint tips were touched against the wet areas of the petrol-soaked jumper, ignition of the petrol vapour still did not occur.

In all three (3) tests when the wet areas of the petrol-soaked jumper were ignited using a lighted cigarette lighter, the naked flame had to be in very close proximity to the area of the garment onto which the petrol had been applied (just several millimetres from the surface) in order for ignition to take place. The most likely reason for this is because the layer of petrol vapour produced at the surface would not be particularly deep since the vapour would tend to descend and accumulate at low level, due to it being more dense than air.

5. Conclusions

The main purpose of this research was to demonstrate visually (for use in court) that ignition of petrol vapour would not occur in the presence of lit commercial and hand-rolled cigarettes, even when puffed. This aim was adequately accomplished by the video footage and photographic images taken throughout the tests.

All of the experiments performed, with the pool of petrol and the liquid petrol applied to a mannequin clothed in a cotton jumper, corroborate the widespread accepted view within the scientific community that a lit cigarette is not a viable ignition source of petrol vapour.

An additional objective of these tests was to investigate whether petrol vapour could be ignited by lit cannabis resin joints and by a single cannabis resin “bomber” (a piece of hot/smouldering cannabis resin). The results of the experiments confirmed the authors’ pro-

position that such mechanisms of ignition of petrol vapour were extremely unlikely.

It is anticipated that this article will assist in countering the above-mentioned commonly held belief, and will illustrate that the likelihood of igniting petrol vapour with lit cigarettes/joints is so unlikely that it can be dismissed as a viable mechanism of ignition. It is also hoped that the results of this research will assist investigators when presented with alternate propositions by a defendant regarding how a petrol-facilitated fire was ignited.

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